

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-321171

(43)Date of publication of application : 24.11.2000

(51)Int.Cl.

G01M 11/02

H04B 10/08

H04B 10/02

H04B 10/18

(21)Application number : 11-129298

(71)Applicant : NEC CORP

(22)Date of filing : 10.05.1999

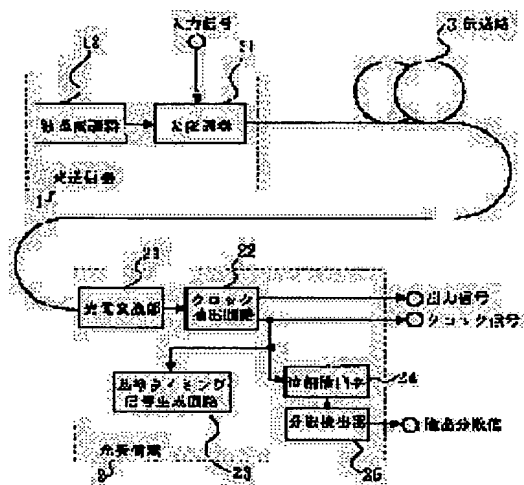
(72)Inventor : SUZAKI TETSUYUKI

(54) APPARATUS AND METHOD FOR MEASUREMENT OF DISPERSION

(57)Abstract:

PROBLEM TO BE SOLVED: To measure the dispersion value of a transmission line between an optical transmitter and an optical receiver.

SOLUTION: A wavelength modulator 12 modulates a wavelength at a prescribed cycle and in a prescribed wavelength modulation amount. Its output light is data-modulated according to an input signal in a light modulator 11 so as to be output as signal light. The signal light is converted into an electric signal by a photoelectric conversion part 21. The electric signal is converted into a clock signal and a reproduced and discriminated output signal by a clock extraction circuit 22. A reference-timing-signal generation circuit 23 generates a reference timing signal which is synchronized with the clock signal outside the measuring time and which holds a phase immediately before a measurement within the measuring time. A phase detector 24 outputs an always constant phase difference outside the measuring time, and it outputs a phase difference which is changed according to the modulation of the wavelength modulator 12 within the measuring time. The output of the phase detector 24 is input to a dispersion detector 25, and a dispersion value in a transmission line is output by using the change amount of the phase difference in the phase detector 24.



LEGAL STATUS

[Date of request for examination]

20.04.2000

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

3379473

[Date of registration] 13.12.2002

[Number of appeal against examiner's decision
of rejection]

[Date of requesting appeal against examiner's
decision of rejection]

[Date of extinction of right]

*** NOTICES ***

JPO and NCIP are not responsible for any damages caused by the use of this translation.

- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.**** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] It is the distributed measuring device which consists of an optical transmitter and an optical receiver and measures the wavelength dispersion in a transmission line. Said optical transmitter It connects with the end of said transmission line, and has the wavelength modulation circuit which adds a modulation to wavelength with a predetermined period to the signal light modulated according to the input signal. Said optical receiver The clock extract circuit which extracts a clock signal based on the signal light which is connected to the other end of said transmission line, and receives, The criteria timing signal generating circuit which generates a criteria timing signal from this clock signal, The phase detector which detects the phase contrast of this clock signal and this criteria timing signal, It has the distributed detector which detects distribution of said transmission line based on the output of this phase detector. Furthermore, said criteria timing signal generating circuit has a voltage controlled oscillator, a phase comparator, and a holding circuit. The output of this voltage controlled oscillator dichotomizes and one of these is connected to one input of said phase comparator. Another side serves as an output of said criteria timing signal generating circuit, and the output of said clock extract circuit is connected to the input of another side of said phase comparator. It is the distributed measuring device characterized by connecting the output of this phase comparator to the input of said holding circuit, for this holding circuit taking out the output of this phase comparator in measuring time outside, and the inside of the measuring time outputting a certain fixed value.

[Claim 2] It is the distributed measuring device which consists of an optical transmitter and an optical receiver and measures the wavelength dispersion in a transmission line. Said optical transmitter It connects with the end of said transmission line, and has the wavelength modulation circuit which adds a modulation to wavelength with a predetermined period to the signal light modulated according to the input signal. Moreover, said receiver The clock extract circuit which extracts a clock signal based on the signal light which is connected to the other end of said transmission line, and receives, The criteria timing signal generating circuit which generates a criteria timing signal from this clock signal, The phase detector which detects the phase contrast of this clock signal and this criteria timing signal, It has the distributed detector which detects distribution of said transmission line based on the output of this phase detector. Furthermore, said criteria timing signal generating circuit includes a voltage controlled oscillator and a holding circuit. The output of this voltage controlled oscillator dichotomizes and one of these is connected to one input of said phase detector. Another side serves as an output of said criteria timing signal generating circuit, and the output of said clock extract circuit is connected to the input of another side of said phase comparator. It is the distributed measuring device characterized by connecting the output of this phase comparator to the input of said holding circuit, for this holding circuit taking out the output of this phase comparator in measuring time outside, and the inside of the measuring time outputting a certain fixed value.

[Claim 3] It is the distributed measuring device which consists of an optical transmitter and an optical receiver and measures the distribution in a transmission line. Said optical transmitter The light modulation circuit which is connected to the end of said transmission line, becomes

irregular according to an input signal and outputs the 1st wavelength as a signal light, The wavelength modulation circuit which is connected to this light modulation circuit and adds a modulation to wavelength with a predetermined period to this signal light, It has the criteria timing signal sending circuit which sends out the criteria timing signal which is a periodic signal which has the frequency of 1 for an integral multiple or an integer to the clock rate of these data using the 2nd wavelength. The optical receiving circuit which said optical receiver is connected to the other end of said transmission line, and receives said 1st wavelength, The clock extract circuit which extracts said clock signal, and the criteria timing signal regenerative circuit which receives said criteria timing signal and performs the playback, The distributed measuring device characterized by having the phase detector which detects the phase contrast of said clock signal and this criteria timing signal, and the distributed detector which detects distribution of said transmission line based on the output of this phase detector.

[Claim 4] The procedure which sends out the signal light which is the distributed measuring method which measures the distribution in the transmission line installed between the optical transmitter and the optical receiver, and was modulated according to the input signal in said optical transmitter, The procedure of changing the delay produced in distribution of this transmission line by adding a modulation with a predetermined period to this signal light this period, The procedure of extracting the clock signal over said signal light in said optical receiver, The procedure which generates the criteria timing signal which is a periodic signal which has the frequency of 1 for N times or N (N is one or more integers) to this clock signal, The distributed measuring method characterized by having the procedure of detecting the phase contrast of the signal of the frequency (M is one or more integers) of 1/M times or M of said clock signal, and said criteria timing signal, and measuring the distribution in said transmission line.

[Claim 5] Said criteria timing signal is a distributed measuring method according to claim 4 which is generated using said clock signal, is carrying out phase simulation to this clock signal in addition to the measuring time, and is characterized by holding the phase in front of measurement initiation during measurement.

[Claim 6] Said optical transmitter to said signal light is a distributed measuring method according to claim 4 or 5 with which it is transmitted to said optical receiver with the wavelength from which said criteria timing signal differs, and said criteria timing signal is characterized by being received and reproduced in this optical receiver.

[Claim 7] The distributed measuring method according to claim 4 to 6 characterized by distribution used as said measuring object being the wavelength dispersion in an optical-fiber-transmission way.

[Translation done.]

* NOTICES *

JPO and NCIP I are not responsible for any damages caused by the use of this translation.

- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.**** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] Especially this invention relates to the in-service distribution measurement which measures wavelength dispersion to that an optic fiber communication system performs data transmission and coincidence about measurement of wavelength dispersion.

[0002]

[Description of the Prior Art] In an optic fiber communication system, the waveform distortion produced by the wavelength dispersion (it is described as "distribution" below) of the optical fiber which is a transmission line becomes the factor which restricts transmission speed and distance. Therefore, distribution of a transmission line is measured with a sufficient precision, and the technique adjusted so that distribution may be made into zero is needed. Furthermore, in an optic fiber communication system, although the both ends of a transmission line are located in a remote location, in order for distribution of an optical fiber to change according to temperature or external pressure, measurement and adjustment of distribution need to be performed into systems operation in a far edge.

[0003] The approach using the monitor light of the wavelength of a transmission signal and different wavelength is proposed using the PM-AM transformation method which fills these demands and which is one of the far-end measuring methods as a Prior art for the distributed detection in systems operation. Here, these techniques are explained using Kuwahara's and others paper (an "examination of adaptation distribution identification method by the distributed fluctuation detection using PM-AM conversion effectiveness" 1998 Institute of Electronics, Information and Communication Engineers communication link society convention, p.417).

[0004] The structure-of-a-system Fig. by this technique is shown in drawing 9 . In drawing 9 , by the transmitting end, it multiplexes by the multiplex circuit 105 and the signal light from the optical transmitter 100 which impressed the high-speed-data signal, and the monitor light which carried out the phase modulation of the semiconductor laser 101 which is the light source of the wavelength of this signal light and different wavelength with the phase modulator 103 by the sinusoidal signal 102 are sent out. Two above-mentioned light which spread the transmission line 104 is separated spectrally in a receiving end by the optical coupler 112 signal light and whose monitor light are separation circuits, incidence of the signal light is carried out to the optical receiver 106, and a data signal is reproduced. the photodetector 108 after monitor light spreads the distributed compensator 107 on the other hand — square — it is detected, asks for the average level of a detecting signal, and the reinforcement of the frequency component of the sinusoidal signal 102, respectively, and asks for distribution from the ratio of these two values.

[0005] In this system, adjustment is performed so that distribution may serve as zero on the wavelength of signal light before employment. Since distribution is not zero in monitor light wave length by the wavelength dependency of distribution at this time, the amount of compensation of the distributed compensator 107 is adjusted so that distribution may be made into zero. if distribution of a transmission line 104 shifts from zero at the time of employment, since the phase modulation of a monitor signal will be changed into intensity modulation by distribution —

the square of the photodetector 108 of a receiving end — the frequency component of the sinusoidal signal 102 appears in a detection output. If a distributed gap is detected, semiconductor laser 101 will be supplied through a control line 109, and control of the wavelength of monitor light will be started by this. Transmission-line distribution serves as zero in the place where the sinusoidal signal frequency component in a detecting signal became zero, and wavelength control is suspended here. Let distribution on this wavelength be zero because only the amount which shifted monitor wavelength at this time shifts signal light wave length. Thus, it detects that distribution shifted from zero.

[0006]

[Problem(s) to be Solved by the Invention] However, there is a trouble which is indicated below with the conventional technique mentioned above.

[0007] First, since signal light wave length differs from monitor light wave length, the wavelength dependency of distribution must arrange these 2 wave in the comparatively narrow wavelength range it can consider that is the same. Consequently, in a multi-wavelength multisystem, two or more monitor wavelength is needed, and it leads to reduction in a transmission band.

[0008] Moreover, the wave of signal light may be distorted by the nonlinearity of the phase-modulation component and optical fiber which are impressed to monitor light.

[0009] This invention is to offer the distributed measuring device and distributed measuring method which can perform simply wavelength dispersion detection in the far edge in systems operation, without being made in view of the trouble which a Prior art which was mentioned above has, and pressing a signal light pattern region.

[0010]

[Means for Solving the Problem] It is the distributed measuring device which the 1st distributed measuring device of this invention consists of an optical transmitter and an optical receiver, and measures the wavelength dispersion in a transmission line. Said optical transmitter It connects with the end of said transmission line, and has the wavelength modulation circuit which adds a modulation to wavelength with a predetermined period to the signal light modulated according to the input signal. Said optical receiver The clock extract circuit which extracts a clock signal based on the signal light which is connected to the other end of said transmission line, and receives, The criteria timing signal generating circuit which generates a criteria timing signal from this clock signal, The phase detector which detects the phase contrast of said clock signal and this criteria timing signal, It has the distributed detector which detects distribution of said transmission line based on the output of this phase detector. Furthermore, said criteria timing signal generating circuit has a voltage controlled oscillator, a phase comparator, and a holding circuit. The output of this voltage controlled oscillator dichotomizes and one of these is connected to one input of said phase comparator. Another side serves as an output of said criteria timing signal generating circuit, and the output of said clock extract circuit is connected to the input of another side of said phase comparator. It is characterized by connecting the output of this phase comparator to the input of said holding circuit, for this holding circuit taking out the output of said phase comparator in measuring time outside, and the inside of the measuring time outputting a certain fixed value.

[0011] It is the distributed measuring device which the 2nd distributed measuring device of this invention consists of an optical transmitter and an optical receiver, and measures the wavelength dispersion in a transmission line. Said optical transmitter It connects with the end of said transmission line, and has the wavelength modulation circuit which adds a modulation to wavelength with a predetermined period to the signal light modulated according to the input signal. Moreover, said receiver The clock extract circuit which extracts a clock signal based on the signal light which is connected to the other end of said transmission line, and receives, The criteria timing signal generating circuit which generates a criteria timing signal from this clock signal, The phase detector which detects the phase contrast of said clock signal and said criteria timing signal, It has the distributed detector which detects distribution of said transmission line based on the output of this phase detector. Furthermore, said criteria timing signal generating circuit includes a voltage controlled oscillator and a holding circuit. The output of this voltage controlled oscillator dichotomizes and one of these is connected to one input of said phase

detector. Another side serves as an output of said criteria timing signal generating circuit, and the output of said clock extract circuit is connected to the input of another side of said phase comparator. It is characterized by connecting the output of this phase comparator to the input of said holding circuit, for this holding circuit taking out the output of this phase comparator in measuring time outside, and the inside of the measuring time outputting a certain fixed value.

[0012] It is the distributed measuring device which the 3rd distributed measuring device of this invention consists of an optical transmitter and an optical receiver, and measures the distribution in a transmission line. Said optical transmitter The light modulation circuit which is connected to the end of said transmission line, becomes irregular according to an input signal and outputs the 1st wavelength as a signal light, The wavelength modulation circuit which is connected to this light modulation circuit and adds a modulation to wavelength with a predetermined period to this signal light, It has the criteria timing signal sending circuit which sends out the criteria timing signal which is a periodic signal which has the frequency of 1 for an integral multiple or an integer to the clock rate of these data using the 2nd wavelength.

Moreover, the optical receiving circuit which said optical receiver is connected to the other end of said transmission line, and receives said 1st wavelength, The clock extract circuit which extracts this clock signal, and the criteria timing signal regenerative circuit which receives said criteria timing signal and performs the playback, It is characterized by having the phase detector which detects the phase contrast of said lock signal and said criteria timing signal, and the distributed detector which detects distribution of said transmission line based on the output of this phase detector.

[0013] The procedure which sends out the signal light which the 1st distributed measuring method of this invention is a distributed measuring method which measures the distribution in the transmission line installed between the optical transmitter and the optical receiver, and was modulated according to the input signal in said optical transmitter, The procedure of changing the delay produced in distribution of this transmission line by adding a modulation with a predetermined period to this signal light this period, The procedure of extracting the clock signal over this signal light in said optical receiver, The procedure which generates the criteria timing signal which is a periodic signal which has the frequency of 1 for N times or N (N is one or more integers) to this clock signal, It has the procedure of detecting the phase contrast of the signal of the frequency (M is one or more integers) of 1/M times or M of this clock signal, and said criteria timing signal, and is characterized by measuring the distribution in said transmission line.

[0014] In the 1st distributed measuring method, said criteria timing signal is generated using said clock signal, and the 2nd distributed measuring method of this invention is carrying out phase simulation to this clock signal in addition to the measuring time, and is characterized by holding the phase in front of measurement initiation during measurement.

[0015] Said criteria timing signal is transmitted to said optical receiver with the wavelength on which the 3rd distributed measuring method of this invention differs from this signal light from said optical transmitter in the 1st distributed measuring method, and this criteria timing signal is characterized by being received and reproduced in this optical receiver.

[0016] The 4th distributed measuring method of this invention is characterized by said measuring object distribution being the wavelength dispersion in an optical-fiber-transmission way in the 1st distributed measuring method.

[0017] An operation of this invention is explained with reference to a drawing. Drawing 8 is for explaining the example applied when the distributed measuring method of this invention measures the wavelength dispersion of a transmission line. The wavelength of the signal light from an optical transmitter is periodically modulated by amount of wavelength modulations $\Delta\lambda$ (nm), as shown in drawing 8 (a). The differential delay X (psec) which will be produced in a transmission line by wavelength amplitude $\Delta\lambda$ supposing this signal light transmits the inside of a transmission line with wavelength dispersion D (psec/nm) and is detected in an optical receiver is $X = D \Delta\lambda$. It is expressed $D \Delta\lambda$.

[0018] Therefore, it is ϕ when this signal light is received, the phase modulation of the clock signal extracted from it is carried out as shown in drawing 8 (b), and the amount ϕ of phase modulations at this time sets the frequency of a clock signal to $f_0 = X / (1/f_0) = X f_0 = \phi$

becomes $D \times \Delta \lambda \times f_0$. On the other hand, it is not based on the modulation in an optical transmitter, but is made [whose criteria timing signal which is a fixed phase is] always like drawing 8 (c). In this example, the frequency of a criteria timing signal is assumed to be the f_0 [same] as a clock signal. At this time, the phase contrast of a clock signal and a criteria timing signal changes with the phase amplitude ϕ periodically like drawing 8 (d).

[0019] Therefore, it is D by detecting this phase contrast ϕ and using amount of wavelength modulations $\Delta \lambda$ in the optical transmitter which is known, and a clock frequency $f_0 = \phi / (\Delta \lambda \times f_0)$

It can carry out and the variance D of a transmission line can be calculated.

[0020] It is possible to calculate the variance of a transmission line like the above on the other hand, by detecting the phase contrast of the dividing clock signal of 1 for the integer of a clock signal and the dividing criteria timing signal of 1 for an integer of a criteria timing signal, when the variance D of a transmission line is large and X is larger than the differential delays $1/f_0$ by it.

[0021]

[Embodiment of the Invention] Next, the gestalt of operation of this invention is explained to a detail with reference to a drawing.

[0022] With reference to drawing 1, the distributed measuring device in which the gestalt of operation of the 1st of this invention is shown is explained. In the optical transmitter 1, the wavelength modulator 12 performs a wavelength modulation by the period f_1 and amount of wavelength modulations $\Delta \lambda$, in an optical modulator 11, the seal of approval of the output light from there is carried out in the data modulation according to an input signal, and it is outputted as a signal light. After this signal light transmits a transmission line 3, it is received by the optical receiver 2.

[0023] In the optical receiver 2, signal light is changed into an electrical signal in the photo-electric-conversion section 21, and is changed into the output signal by which playback discernment was carried out with the clock signal in the clock extract circuit 22. A clock signal is inputted into the criteria timing signal generation circuit 23 and a phase detector 24. In this criteria timing signal generation circuit 23, it synchronizes with a clock signal besides the measuring time, and a criteria timing signal which holds the phase in front of measurement in the measuring time is generated. Although fixed phase contrast is always outputted out of the measuring time in a phase detector 24, in the measuring time, the phase contrast which changes according to the modulation of the wavelength modulator 12 is outputted. The output of this phase detector 24 is inputted into the distributed detector 25, and the distributed detector 25 outputs the variance in a transmission line using the variation of the phase contrast in a phase detector 24 based on the frequency f_0 of amount of wavelength modulations $\Delta \lambda$ which is known, and a clock signal.

[0024] Drawing 2 shows one example of the criteria timing signal generation circuit 23 in the above-mentioned distributed measuring device. Here, the input of the criteria timing signal generation circuit 23, i.e., a clock signal, is inputted into one input terminal of a phase comparator 31, and the output is inputted into a holding circuit 32. A control signal is inputted into a holding circuit 32, and the output of a holding circuit 32 is inputted into a voltage controlled oscillator 34. The output of a voltage controlled oscillator 34 dichotomizes, one side is outputted as a criteria timing signal, and another side is connected to the input of another side of a phase comparator 31.

[0025] Actuation of this distributed measuring device is explained in detail using drawing 3. This example explains the case where the above-mentioned wavelength modulation is always performed. As shown in drawing 3 (a), to signal light, the wavelength modulation is performed by amount of wavelength modulations $\Delta \lambda$, and as the wavelength dispersion in a transmission line shows to a clock signal at drawing 3 (b), thereby, a phase modulation is performed in the amount ϕ of phase modulations as mentioned above. At this time, as shown in drawing 3 (c), in the measuring time, a control signal is added to a holding circuit 32. Here, although a voltage controlled oscillator 34 carries out phase simulation to a clock signal in order that a holding circuit 32 may take out an input signal as it is when a control signal is OFF, as shown in drawing 3 (d), when a control signal is ON, a holding circuit 32 holds the output of the

phase comparator 31 in front of that, and, thereby, becomes fixed [the phase of a voltage controlled oscillator 34]. Thereby, the variance of a transmission line can be measured like the above-mentioned explanation by detecting the phase contrast of a clock signal and a criteria timing signal in the measuring time.

[0026] In this example, it was possible by setting it as the amount of wavelength modulations of 0.1nm, its modulation period of 10kHz, and measuring-time 1sec in a distributed shift fiber with a die length of 400km to have measured **250 psec/nm from 0 as a variance of a transmission line as transmission-speed 40 Gb/s of the data which signal light transmits, and a transmission line.

[0027] Next, the gestalt of operation of the 2nd of this invention is explained using drawing 4 . In this distributed measuring device, the criteria timing signal generator 23-1 consists of a voltage controlled oscillator 34 and a holding circuit 32. The configuration of the photo-electric-conversion section 21 in the optical transmitter 1, a transmission line 3, and the optical receiver 2-1 and the clock extractor 22 is the same as the thing in the gestalt of the 1st operation. The output of the clock extract circuit 22 is connected to one input terminal of a phase detector 24, and the output of the voltage controlled oscillator 34 in the criteria timing signal generator 23-1 is connected to the input terminal of another side of a phase detector 24. The output of a phase detector 24 dichotomizes, one side is connected to the distributed detector 25, and another side is connected to a holding circuit 32. The output of a holding circuit 32 is connected to the input of a voltage controlled oscillator 34. The detected variance is outputted from the distributed detector 25. Although the gestalt of this operation had the wavelength dispersion detection property equivalent to the gestalt of the 1st operation, since the phase comparator 31 in the gestalt of the 1st operation was deleted, the miniaturization of much more equipment was realized.

[0028] Next, the gestalt of operation of the 3rd of this invention is explained using drawing 5 . The configuration of the photo-electric-conversion section 21 in the optical transmitter 1, a transmission line 3, and the optical receiver 2-2 and the clock extractor 22 of this distributed measuring device is the same as that of the thing in the gestalt of the 1st operation. On the other hand, unlike the gestalt of the 1st operation, the output of the clock extract circuit 22 is connected to one input terminal of a phase detector 24 through the 1st frequency divider 41, and the output of the criteria timing signal generation circuit 23 is connected to the input terminal of another side of a phase detector 24 through the 2nd frequency divider 42. In this equipment, it was set as the amount of wavelength modulations of 0.1nm, its modulation period of 10kHz, and measuring-time 1sec in the single mode fiber with a die length of 80km as transmission-speed 40 Gb/s of the data which signal light transmits, and a transmission line. Moreover, when the dividing ratio of the 1st frequency divider 41 and the 2nd frequency divider 42 was set as 1/16, the measurable distributed range was set to **4000 pec/nm which hits 16 times also in the gestalt of the 1st operation.

[0029] Next, the gestalt of operation of the 4th of this invention is explained using drawing 6 . In the optical transmitter 1-1, the wavelength modulator 12 performs a wavelength modulation by the period f_1 and amount of wavelength modulations $\Delta\lambda$ to the 1st wavelength λ_1 , in an optical modulator 11, the seal of approval of the output light from there is carried out in the data modulation according to an input signal, and it is outputted as a signal light. Moreover, in the criteria timing signal sending circuit 53, the criteria timing signal by which phase simulation was carried out to the input signal with the frequency equal to the clock frequency of an input signal is generated, and it outputs as a criteria timing signal light using wavelength λ_2 . a signal — **** — calling — wavelength multiplexing of the criteria timing signal light is carried out by the multiplex circuit 51, and it transmits a transmission line 3.

[0030] In the optical receiver 2-3, wavelength separation is first carried out by the separation circuit 52, and it is divided into signal light and criteria timing signal light. Signal light is changed into an electrical signal in the photo-electric-conversion section 21, and is changed into the output signal by which playback discernment was carried out with the clock signal in the clock extract circuit 22. On the other hand, photo electric conversion of the criteria timing signal light is carried out by the criteria timing signal receiving circuit 54, and it is reproduced as a criteria

timing signal. The output of the clock extract circuit 22 and the output of the criteria timing signal receiving circuit 54 are inputted into a phase detector 24. The output of this phase detector 24 is inputted into the distributed detector 25, and this distributed detector 25 outputs the variance in a transmission line using the variation of the phase contrast in a phase detector 24 based on the wavelength amplitude ($\lambda_1 - \lambda_2$) which is known, and the frequency f_0 of a clock signal.

[0031] In this equipment, the time amount which measures distribution from the 1st unlike the gestalt of the 3rd operation becomes that it is not limited and always possible. Moreover, since the criteria timing signal generation circuit 23 which contains a voltage controlled oscillator 34 in the optical receiver 2 becomes unnecessary, stability has been improved further. At this time, it was possible as transmission-speed 40 Gb/s and a transmission line to have measured ≈ 250 psec/nm from 0 as a variance of a transmission line by setting it as the amount of wavelength modulations of 0.1nm, and its modulation period of 10kHz in a distributed shift fiber with a die length of 400km.

[0032] Next, the gestalt of operation of the 5th of this invention is explained using drawing 7. The optical transmitter 1-2 in this distributed measuring device includes the same criteria timing signal sending circuit 53 as the 1st data modulation section 81 which consists of the 1st optical modulator 61 and the 1st wavelength modulator 62, and generates the 1st output light from the 1st input signal, the data modulation sections 82 from the 2nd with the same configuration as it to the Nth, and in the gestalt of the 4th operation. Here, phase simulation of the 1st to Nth input signal and criteria timing signal is carried out. The data modulation sections and the criteria timing signal sending circuits 53 from the 1st to the Nth output respectively different wavelength, wavelength multiplexing of them is carried out by the multiplex circuit 51, and they are transmitted.

[0033] The 1st data recovery section 85 which consists of the 1st photo-electric-conversion section 71, the 1st clock extractor 72, the 1st phase detector 73, and the 1st distributed detector 74, and outputs the 1st output signal and 1st clock signal in the optical receiver 2-4. The same criteria timing signal receiving circuit 54 as the Nth data recovery section 86 and in the gestalt of the 4th operation is included from the 2nd with the same configuration as it. N branching is carried out and the output of the criteria timing signal receiving circuit 54 is inputted into one terminal of the Nth phase detector from the 1st, respectively.

[0034] Unlike the gestalt of the 4th operation, in this equipment, it was detectable from each 1st [the] by which wavelength multiplexing was carried out with the property same in the gestalt of the 4th operation of the variance in each wavelength of the Nth signal light.

[0035] As mentioned above, although the distributed measuring device of this invention and the gestalt of operation of a distributed measuring method were explained, this invention is realizable with other various modes.

[0036] First, although the distributed measuring method of this invention was explained as what measures wavelength dispersion, this is an effective approach also to the other various distributions, for example, polarization distribution, mode dispersion, etc.

[0037] Moreover, in the distributed measuring device of this invention, although the case where a clock signal and a criteria timing signal were the same frequencies was explained, this can be applied, also when the relation is 1 for the integral multiple or an integer.

[0038] Moreover, a possible thing cannot be overemphasized no matter what passive circuit elements it may apply, if the function is filled about various circuits in this invention, and components.

[0039]

[Effect of the Invention] The 1st effectiveness of this invention is making it possible to measure the variance in the wavelength transmitted in the operations system with which data are actually transmitted, without lowering the data quality transmitted.

[0040] Moreover, the 2nd effectiveness is in a far edge, i.e., also in a transmission system which has a long transmission line between an optical transmitter and an optical receiver, it is supposing that it is possible to measure the variance of a transmission line.

[0041] Moreover, the 3rd effectiveness is that a distributed measuring device can be easily

realized with the combination of general-purpose components.

[Translation done.]

*** NOTICES ***

JPO and NCIP I are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing showing the gestalt of operation of the 1st of this invention

[Drawing 2] Drawing showing the configuration of the criteria timing signal generation circuit in the gestalt of operation of the 1st of this invention

[Drawing 3] Drawing explaining actuation of the gestalt of the 1st operation in this invention

[Drawing 4] Drawing showing the gestalt of operation of the 2nd of this invention

[Drawing 5] Drawing showing the gestalt of operation of the 3rd of this invention

[Drawing 6] Drawing showing the gestalt of operation of the 4th of this invention

[Drawing 7] Drawing showing the gestalt of operation of the 5th of this invention

[Drawing 8] Drawing for explaining an operation of this invention

[Drawing 9] Drawing showing the conventional example

[Description of Notations]

1 Optical Transmitter

1-1 Optical Transmitter

1-2 Optical Transmitter

2 Optical Receiver

2-1 Optical Receiver

2-2 Optical Receiver

2-3 Optical Receiver

2-4 Optical Receiver

3 Transmission Line

11 Optical Modulator

12 Wavelength Modulator

21 Photo-Electric-Conversion Section

22 Clock Extract Circuit

23 Criteria Timing Signal Generation Circuit

24 Phase Detector

25 Distributed Detector

31 Phase Comparator

32 Holding Circuit

34 Voltage Controlled Oscillator

41 1st Frequency Divider

42 2nd Frequency Divider

51 Multiplex Circuit

52 Separation Circuit

53 Criteria Timing Signal Sending Circuit

54 Criteria Timing Signal Receiving Circuit

61 1st Optical Modulator

62 1st Wavelength Modulator

63 Nth Optical Modulator

64 Nth Wavelength Modulator

71 1st Photo-Electric-Conversion Section
72 1st Clock Extract Circuit
73 1st Phase Detector
74 1st Distributed Detector
75 Nth Photo-Electric-Conversion Section
76 Nth Clock Extract Circuit
77 Nth Phase Detector
78 Nth Distributed Detector
81 1st Data Modulation Section
82 Nth Data Modulation Section
85 1st Data Recovery Section
86 Nth Data Recovery Section
100 Optical Transmitter
101 Semiconductor Laser
102 Sinusoidal Signal
103 Optical Phase Modulator
104 Transmission Line
105 Multiplex Circuit
106 Optical Receiver
107 Distributed Compensator
108 Photodetector
109 Control Line
110 Band Pass Filter
111 Average Detector
112 Optical Coupler

[Translation done.]

* NOTICES *

JPO and NCIP are not responsible for any damages caused by the use of this translation.

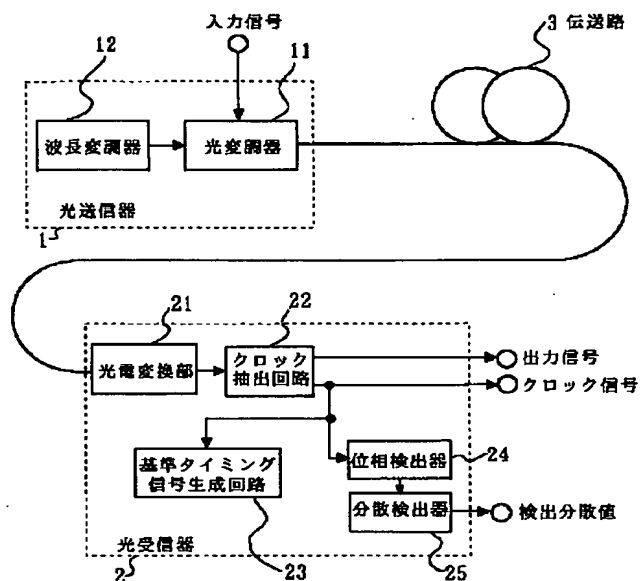
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

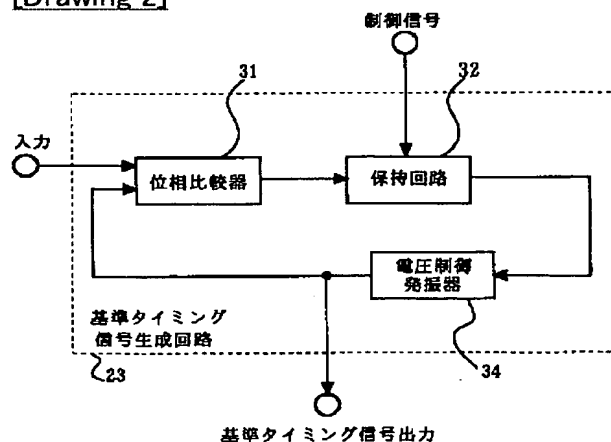
3.In the drawings, any words are not translated.

DRAWINGS

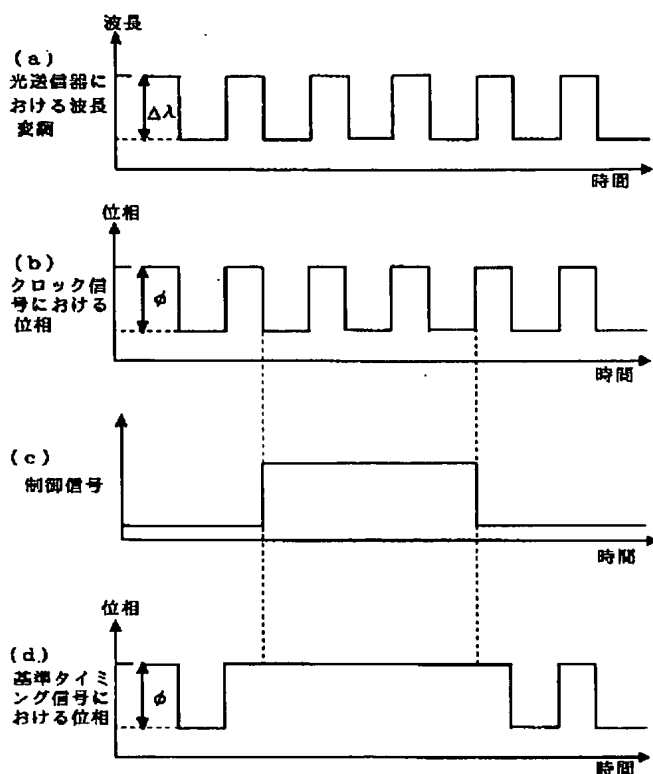
[Drawing 1]



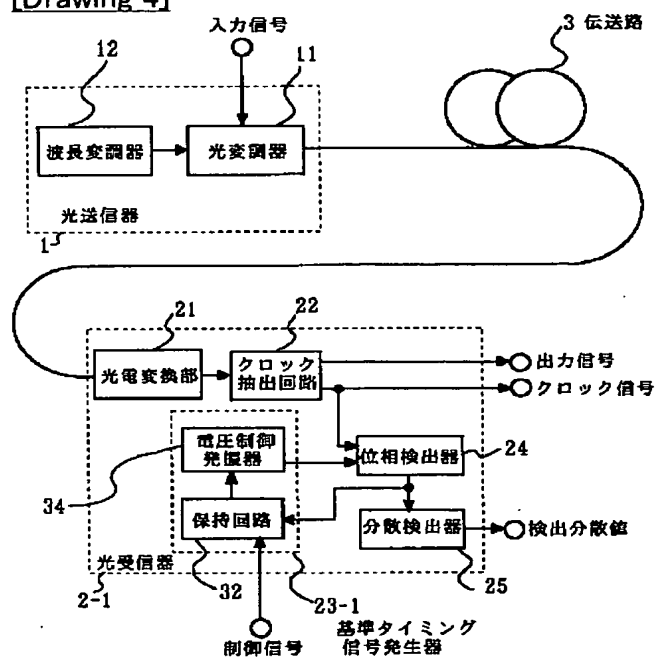
[Drawing 2]



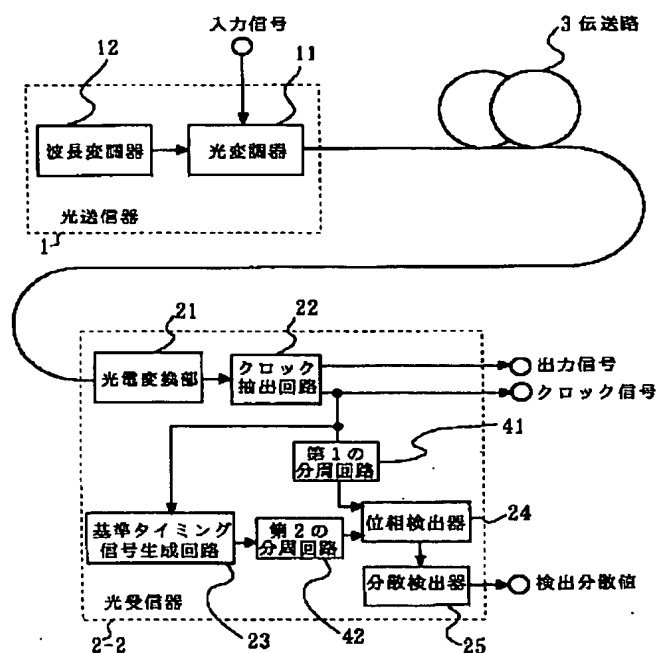
[Drawing 3]



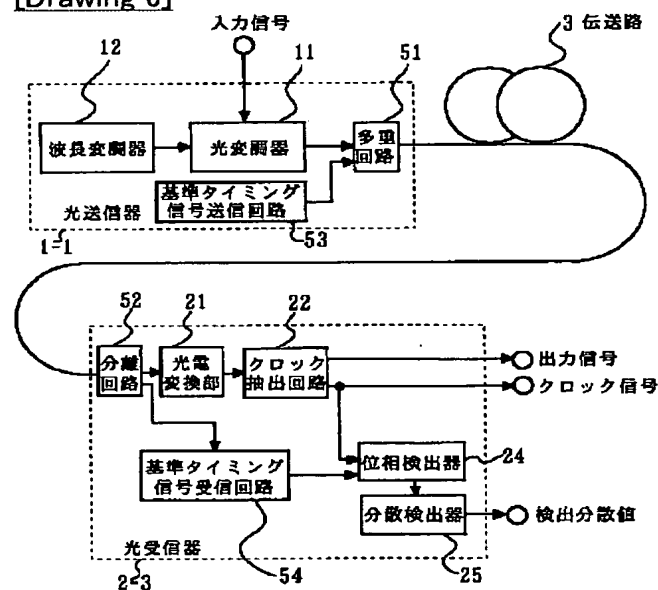
[Drawing 4]



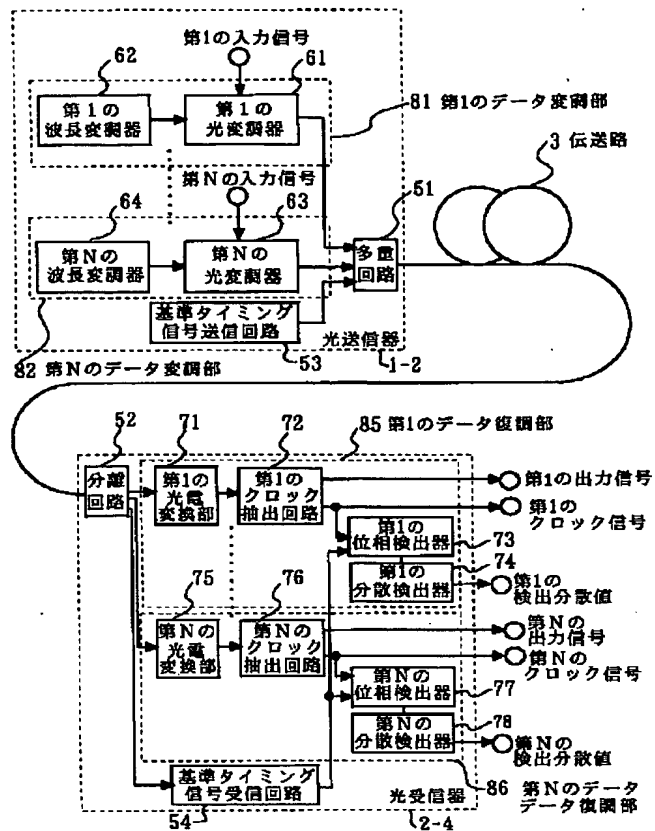
[Drawing 5]



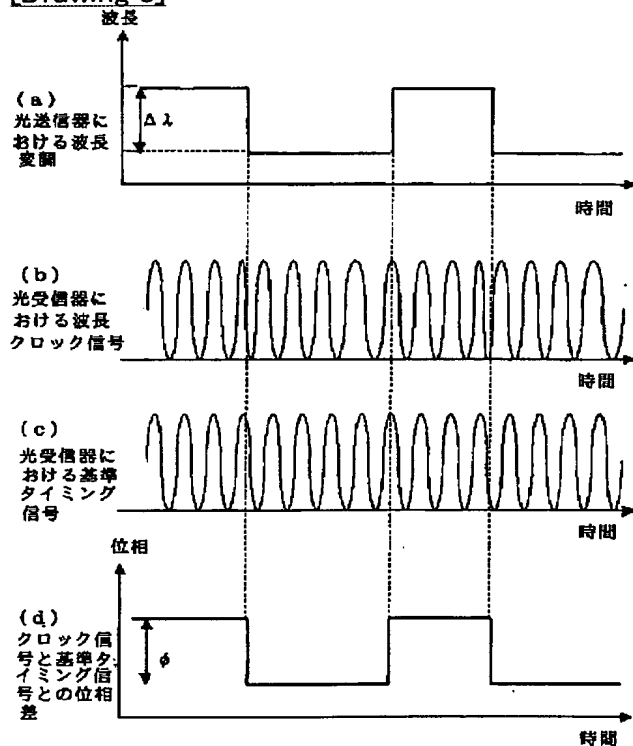
[Drawing 6]



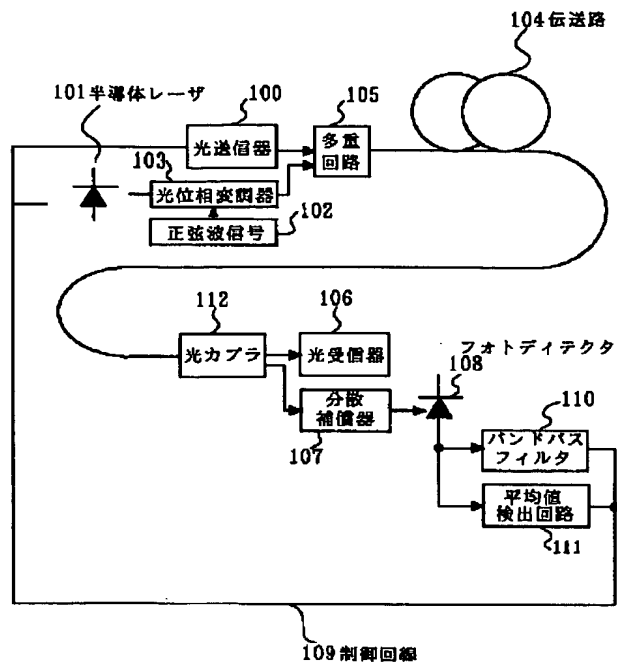
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開2000-321171

(P2000-321171A)

(43) 公開日 平成12年11月24日 (2000. 11. 24)

(51) Int.Cl.

識別記号

F I

テーマコード (参考)

G 0 1 M 11/02

G 0 1 M 11/02

K 5 K 0 0 2

H 0 4 B 10/08

H 0 4 B 9/00

K

10/02

M

10/18

審査請求 有 請求項の数 7 O L (全 9 頁)

(21) 出願番号

特願平11-129298

(22) 出願日

平成11年 5 月10日 (1999. 5. 10)

(71) 出願人 000004237

日本電気株式会社

東京都港区芝五丁目 7 番 1 号

(72) 発明者 洲崎 哲行

東京都港区芝五丁目 7 番 1 号 日本電気株式会社内

(74) 代理人 100108578

弁理士 高橋 昭男 (外 3 名)

Fターム (参考) 5K002 AA02 AA04 CA01 CA14 DA05

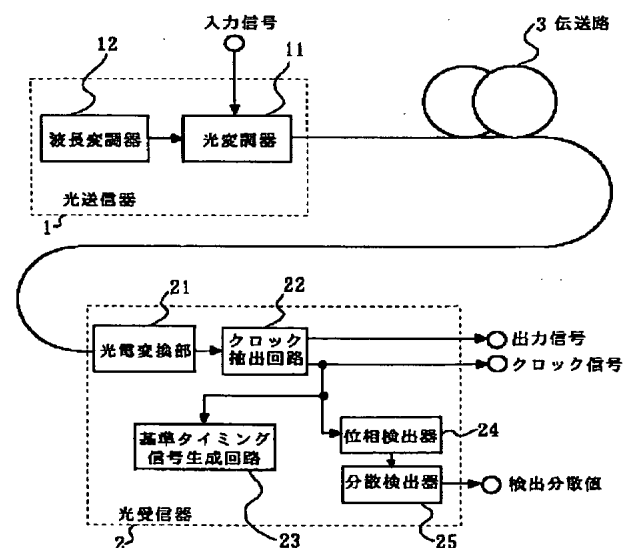
EA05 FA01

(54) 【発明の名称】 分散測定装置および分散測定方法

(57) 【要約】

【課題】 光送信器と光受信器間の伝送路の分散値を運用中に測定する。

【解決手段】 波長変調器 12 は周期 f_1 、波長変調量 $\Delta \lambda$ で波長変調を行い、その出力光は光変調器 11 において入力信号に応じたデータ変調を印加され、信号光として出力される。この信号光は光電変換部 21 において電気信号に変換され、クロック抽出回路 22 により、クロック信号と再生識別された出力信号に変換される。基準タイミング信号生成回路 23 は、測定時間外ではクロック信号に同期し測定時間では測定の直前の位相を保持するような基準タイミング信号を生成する。位相検出器 24 は測定時間外では常に一定の位相差を出力するが、測定時間内には波長変調器 12 の変調に応じて変化する位相差を出力する。位相検出器 24 の出力は分散検出器 25 に入力され、位相検出器 24 における位相差の変化量を用いて伝送路における分散値が出力される。



【特許請求の範囲】

【請求項1】 光送信器と光受信器とから成り、伝送路における波長分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、入力信号に応じて変調された信号光に対して所定の周期で波長に変調を加える波長変調回路を有し、前記光受信器は、前記伝送路の他端に接続され、受信する信号光を基にクロック信号を抽出するクロック抽出回路と、該クロック信号から基準タイミング信号を生成する基準タイミング信号発生回路と、該クロック信号と該基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有し、さらに、前記基準タイミング信号発生回路が電圧制御発振器と位相比較器と保持回路とを有し、該電圧制御発振器の出力が2分岐され、その一方が前記位相比較器の一方の入力に接続され、他方が前記基準タイミング信号発生回路の出力となり、前記クロック抽出回路の出力が前記位相比較器の他方の入力に接続され、該位相比較器の出力が前記保持回路の入力に接続され、該保持回路は測定時間外は該位相比較器の出力を出し測定時間中はある一定の値を出力することを特徴とする分散測定装置。

【請求項2】 光送信器と光受信器とから成り、伝送路における波長分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、入力信号に応じて変調された信号光に対して所定の周期で波長に変調を加える波長変調回路を有し、また、前記受信器は、前記伝送路の他端に接続され、受信する信号光を基にクロック信号を抽出するクロック抽出回路と、該クロック信号から基準タイミング信号を生成する基準タイミング信号発生回路と、該クロック信号と該基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有し、さらに、前記基準タイミング信号発生回路が電圧制御発振器と保持回路とを含み、該電圧制御発振器の出力が2分岐され、その一方が前記位相検出器の一方の入力に接続され、他方が前記基準タイミング信号発生回路の出力となり、前記クロック抽出回路の出力が前記位相比較器の他方の入力に接続され、該位相比較器の出力が前記保持回路の入力に接続され、該保持回路は測定時間外は該位相比較器の出力を出し測定時間中はある一定の値を出力することを特徴とする分散測定装置。

【請求項3】 光送信器と光受信器とから成り、伝送路

における分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、第1の波長を入力信号に応じて変調し信号光として出力する光変調回路と、該光変調回路に接続され、該信号光に対して所定の周期で波長に変調を加える波長変調回路と、該データのクロック速度に対して整数倍あるいは整数分の1の周波数を有する周期信号である基準タイミング信号を第2の波長を用いて送出する基準タイミング信号送信回路とを有し、前記光受信器は、前記伝送路の他端に接続され前記第1の波長を受信する光受信回路と、前記クロック信号を抽出するクロック抽出回路と、前記基準タイミング信号を受信しその再生を行う基準タイミング信号再生回路と、前記クロック信号と該基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有することを特徴とする分散測定装置。

【請求項4】 光送信器と光受信器との間に設置された伝送路における分散を測定する分散測定方法であって、前記光送信器において入力信号に応じて変調された信号光を送出する手順と、該信号光に対して所定の周期で変調を加えることにより該伝送路の分散で生じる遅延を該周期で変化させる手順と、前記光受信器において前記信号光に対するクロック信号を抽出する手順と、該クロック信号に対してN倍あるいはN分の1の周波数（Nは1以上の整数）を有する周期信号である基準タイミング信号を生成する手順と、前記クロック信号のM倍あるいはM分の1の周波数（Mは1以上の整数）の信号と前記基準タイミング信号との位相差を検出する手順とを有し、前記伝送路における分散を測定することを特徴とする分散測定方法。

【請求項5】 前記基準タイミング信号は前記クロック信号を用いて生成され、測定時間以外において該クロック信号と位相同期しており、測定中は測定開始直前の位相を保持していることを特徴とする請求項4記載の分散測定方法。

【請求項6】 前記基準タイミング信号は、前記光送信器から前記信号光とは異なる波長により前記光受信器に伝送され、前記基準タイミング信号は該光受信器において受信および再生されることを特徴とする請求項4または5記載の分散測定方法。

【請求項7】 前記測定対象となる分散が光ファイバ伝送路における波長分散であることを特徴とする請求項4ないし6のいずれかに記載の分散測定方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、波長分散の測定に関し、特に、光ファイバ通信システムでデータ伝送を行うのと同時に波長分散を測定するインサースペクトル測定に関する。

【0002】

【従来の技術】光ファイバ通信システムにおいては、伝送路である光ファイバの波長分散（以下「分散」と記す）によって生じる波形歪が伝送速度や距離を制限する要因となる。従って、伝送路の分散を精度よく測定し、分散を零とするように調整する技術が必要とされる。さらに、光ファイバ通信システムでは、伝送路の両端が遠隔の場所にあるが、光ファイバの分散は温度や外圧に応じて変化するため、分散の測定および調整は遠端にてシステム運用中に行われる必要がある。

【0003】これらの要求を満たす従来の技術として、遠端測定法の一つであるPM-AM変換法を用い、システム運用中の分散検出のため、伝送信号の波長と異なる波長のモニタ光を用いる方法が提案されている。ここでは、桑原らの論文（「PM-AM変換効果を用いた分散変動検出による適応分散等化方式の検討」、1998年電子情報通信学会通信ソサイエティ大会、p.417）を用いて、これらの技術を説明する。

【0004】図9に、この技術によるシステムの構成図を示す。図9において、送信端では、高速データ信号を印加した光送信器100からの信号光と、この信号光の波長と異なる波長の光源である半導体レーザ101を正弦波信号102で位相変調器103により位相変調したモニタ光とを多重回路105により合波して送り出す。伝送路104を伝搬した上述の2つの光は、受信端において信号光とモニタ光が分離回路である光カプラ112により分波され、信号光は光受信器106に入射されデータ信号が再生される。一方、モニタ光は、分散補償器107を伝搬した後、フォトディテクタ108によって自乗検波され、検出信号の平均レベルおよび正弦波信号102の周波数成分の強度をそれぞれ求め、これら2つの値の比から分散を求める。

【0005】このシステムでは、運用前に信号光の波長で分散が零となるよう調整が行われる。このとき、分散の波長依存性によってモニタ光波長で分散が零ではないため、分散を零とするよう分散補償器107の補償量を調節する。運用時に、伝送路104の分散が零からずれると、モニタ信号の位相変調が分散によって強度変調に変換されるため、受信端のフォトディテクタ108の自乗検波出力に正弦波信号102の周波数成分が現れる。分散ずれが検出されると、制御回線109を通して半導体レーザ101に供給され、これによってモニタ光の波長の制御を開始する。検出信号の中の正弦波信号周波数成分が零となったところで伝送路分散が零となり、こ

で波長制御を停止する。このときモニタ波長をずらした量だけ信号光波長をずらすことで、この波長での分散を零とする。このようにして、分散が零からずれたことを検出する。

【0006】

【発明が解決しようとする課題】しかしながら、上述した従来技術では、以下に記載するような問題点がある。

【0007】まず、信号光波長とモニタ光波長が異なっているため、分散の波長依存性が同じとみなせる比較的狭い波長範囲にこれら2波を配置しなければならない。この結果、多波長多重システムにおいては複数のモニタ波長が必要となり、伝送帯域の減少につながる。

【0008】また、モニタ光に印加する位相変調成分と光ファイバの非線形性によって、信号光の波形が歪む可能性がある。

【0009】本発明は、上述したような従来の技術が有する問題点に鑑みてなされたものであって、信号光帯域を圧迫することなく、システム運用中の遠端での波長分散検出を簡易に行なうことができる分散測定装置および分散測定方法を提供することにある。

【0010】

【課題を解決するための手段】本発明の第1の分散測定装置は、光送信器と光受信器とから成り、伝送路における波長分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、入力信号に応じて変調された信号光に対して所定の周期で波長に変調を加える波長変調回路を有し、前記光受信器は、前記伝送路の他端に接続され、受信する信号光を基にクロック信号を抽出するクロック抽出回路と、該クロック信号から基準タイミング信号を生成する基準タイミング信号発生回路と、前記クロック信号と該基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有し、さらに、前記基準タイミング信号発生回路は電圧制御発振器と位相比較器と保持回路とを有し、該電圧制御発振器の出力が2分岐され、その一方が前記位相比較器の一方の入力に接続され、他方が前記基準タイミング信号発生回路の出力となり、前記クロック抽出回路の出力が前記位相比較器の他方の入力に接続され、該位相比較器の出力が前記保持回路の入力に接続され、該保持回路は測定時間外は前記位相比較器の出力を出し測定時間中はある一定の値を出力することを特徴とする。

【0011】本発明の第2の分散測定装置は、光送信器と光受信器とから成り、伝送路における波長分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、入力信号に応じて変調された信号光に対して所定の周期で波長に変調を加える波長変調回路を有し、また、前記受信器は、前記伝送路の他端に接続され、受信する信号光を基にクロック信号を抽出するクロック抽出回路と、該クロック信号から基準タイミン

グ信号を生成する基準タイミング信号発生回路と、前記クロック信号と前記基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有し、さらに、前記基準タイミング信号発生回路は電圧制御発振器と保持回路とを含み、該電圧制御発振器の出力が2分岐され、その一方が前記位相検出器の一方の入力に接続され、他方が前記基準タイミング信号発生回路の出力となり、前記クロック抽出回路の出力が前記位相比較器の他方の入力に接続され、該位相比較器の出力が前記保持回路の入力に接続され、該保持回路は測定時間外は該位相比較器の出力を出し測定時間中はある一定の値を出力することを特徴とする。

【0012】本発明の第3の分散測定装置は、光送信器と光受信器とから成り、伝送路における分散を測定する分散測定装置であって、前記光送信器は、前記伝送路の一端に接続され、第1の波長を入力信号に応じて変調し信号光として出力する光変調回路と、該光変調回路に接続され、該信号光に対して所定の周期で波長に変調を加える波長変調回路と、該データのクロック速度に対して整数倍あるいは整数分の1の周波数を有する周期信号である基準タイミング信号を第2の波長を用いて送出する基準タイミング信号送信回路とを有し、また、前記光受信器は、前記伝送路の他端に接続され前記第1の波長を受信する光受信回路と、該クロック信号を抽出するクロック抽出回路と、前記基準タイミング信号を受信しその再生を行う基準タイミング信号再生回路と、前記クロック信号と前記基準タイミング信号との位相差を検出する位相検出器と、該位相検出器の出力を基に前記伝送路の分散を検出する分散検出器とを有することを特徴とする。

【0013】本発明の第1の分散測定方法は、光送信器と光受信器との間に設置された伝送路における分散を測定する分散測定方法であって、前記光送信器において入力信号に応じて変調された信号光を送出する手順と、該信号光に対して所定の周期で変調を加えることにより該伝送路の分散で生じる遅延を該周期で変化させる手順と、前記光受信器において該信号光に対するクロック信号を抽出する手順と、該クロック信号に対してN倍あるいはN分の1の周波数(Nは1以上の整数)を有する周期信号である基準タイミング信号を生成する手順と、該クロック信号のM倍あるいはM分の1の周波数(Mは1以上の整数)の信号と前記基準タイミング信号との位相差を検出する手順とを有し、前記伝送路における分散を測定することを特徴とする。

【0014】本発明の第2の分散測定方法は、第1の分散測定方法において、前記基準タイミング信号は前記クロック信号を用いて生成され、測定時間以外において該クロック信号と位相同期しており、測定中は測定開始直前の位相を保持していることを特徴とする。

【0015】本発明の第3の分散測定方法は、第1の分

散測定方法において、前記基準タイミング信号は、前記光送信器から該信号光とは異なる波長により前記光受信器に伝送され、該基準タイミング信号は該光受信器において受信および再生されることを特徴とする。

【0016】本発明の第4の分散測定方法は、第1の分散測定方法において、前記測定対象分散が光ファイバ伝送路における波長分散であることを特徴とする。

【0017】本発明の作用を図面を参照して説明する。図8は、本発明の分散測定方法が、伝送路の波長分散を測定する場合に適用される例を説明するためのものである。光送信器からの信号光の波長を図8(a)に示すように、波長変調量 $\Delta\lambda$ (nm)で周期的に変調する。この信号光が波長分散D(psec/nm)を持った伝送路中を伝送し光受信器において検出されるとすると、波長振幅 $\Delta\lambda$ により伝送路において生じる遅延差X(psec)は、

$$X = D \times \Delta\lambda$$

と表される。

【0018】よって、この信号光を受信し、それより抽出されたクロック信号は図8(b)に示すように位相変調され、この時の位相変調量 ϕ はクロック信号の周波数をf0とすると、

$$\phi = X / (1/f0) = X \times f0 = D \times \Delta\lambda \times f0$$

となる。一方、光送信器における変調によらず常に一定の位相である基準タイミング信号が図8(c)のようであるとする。この例では基準タイミング信号の周波数はクロック信号と同じf0と仮定する。この時、クロック信号と基準タイミング信号との位相差は図8(d)のように周期的に位相振幅 ϕ で変化する。

【0019】よって、この位相差 ϕ を検出し、既知である光送信器における波長変調量 $\Delta\lambda$ と、クロック周波数f0を用いることにより、

$$D = \phi / (\Delta\lambda \times f0)$$

として伝送路の分散値Dを求めることができる。

【0020】一方、伝送路の分散値Dが大きく、それによる遅延差Xが $1/f0$ より大きいときには、クロック信号の整数分の1の分周クロック信号と、基準タイミング信号の整数分の1の分周基準タイミング信号との位相差を検出することにより、上記と同様に伝送路の分散値を求めることが可能である。

【0021】

【発明の実施の形態】次に、本発明の実施の形態について図面を参照して詳細に説明する。

【0022】図1を参照して、本発明の第1の実施の形態を示す分散測定装置について説明する。光送信器1において、波長変調器12は周期f1および波長変調量 $\Delta\lambda$ で波長変調を行い、そこからの出力光は光変調器11において入力信号に応じたデータ変調を印可され、信号光として出力される。この信号光は伝送路3を伝送した

後、光受信器2により受信される。

【0023】光受信器2においては、信号光は光電変換部21において電気信号に変換され、クロック抽出回路22により、クロック信号と再生識別された出力信号に変換される。クロック信号は基準タイミング信号生成回路23と位相検出器24に入力される。この基準タイミング信号生成回路23においては、測定時間外においてはクロック信号に同期し、測定時間においては測定の直前の位相を保持するような基準タイミング信号を生成する。位相検出器24においては測定時間外では常に一定の位相差を出力するが、測定時間内には波長変調器12の変調に応じて変化する位相差を出力する。この位相検出器24の出力は分散検出器25に入力され、分散検出器25は、既知である波長変調量 $\Delta\lambda$ とクロック信号の周波数 f_0 を元に、位相検出器24における位相差の変化量を用いて伝送路における分散値を出力する。

【0024】図2は上記の分散測定装置内の基準タイミング信号生成回路23の一実施例を示すものである。ここで、基準タイミング信号生成回路23の入力、すなわちクロック信号は位相比較器31の一方の入力端子に入力され、その出力は保持回路32に入力される。保持回路32には制御信号が入力され、保持回路32の出力は電圧制御発振器34に入力される。電圧制御発振器34の出力は2分岐され、一方は基準タイミング信号として出力され、他方は位相比較器31の他方の入力に接続される。

【0025】この分散測定装置の動作を図3を用いて詳しく説明する。この例では上記の波長変調が常に行われている場合について説明する。図3(a)に示すように、信号光に対しては波長変調量 $\Delta\lambda$ で波長変調が行われており、これにより前述のように、伝送路中の波長分散によりクロック信号には図3(b)に示すように位相変調量 ϕ で位相変調が施される。このとき、図3(c)に示すように、測定時間において保持回路32に制御信号を加える。ここで、図3(d)に示すように、制御信号がオフの場合は保持回路32は入力信号をそのまま出すため、電圧制御発振器34はクロック信号に対して位相同期するが、制御信号がオンの場合は保持回路32がその直前の位相比較器31の出力を保持し、それにより電圧制御発振器34の位相は一定となる。これにより、前述の説明のように、測定時間においてクロック信号と基準タイミング信号の位相差を検出することにより、伝送路の分散値を測定することができる。

【0026】本実施例においては、信号光が伝達するデータの伝送速度40Gb/s、伝送路として長さ400kmの分散シフトファイバにおいて、波長変調量0.1nm、その変調周期10kHz、測定時間1secに設定することにより、伝送路の分散値として0から ± 250 pssec/nmを測定することが可能であった。

【0027】次に、図4を用いて本発明の第2の実施の

形態について説明する。この分散測定装置は、基準タイミング信号発生器23-1は電圧制御発振器34と保持回路32から成る。光送信器1、伝送路3、光受信器2-1内の光電変換部21およびクロック抽出器22の構成は第1の実施の形態におけるものと同じである。クロック抽出回路22の出力は位相検出器24の一方の入力端子に接続され、基準タイミング信号発生器23-1内の電圧制御発振器34の出力は位相検出器24の他方の入力端子に接続される。位相検出器24の出力は2分岐され、一方は分散検出器25に、他方は保持回路32に接続される。保持回路32の出力は電圧制御発振器34の入力に接続される。分散検出器25からは検出された分散値が出力される。本実施の形態は第1の実施の形態と同等の波長分散検出特性を有するが、第1の実施の形態における位相比較器31が削除されたため、より一層の装置の小型化が実現された。

【0028】次に、図5を用いて、本発明の第3の実施の形態について説明する。本分散測定装置は、光送信器1、伝送路3、光受信器2-2内の光電変換部21およびクロック抽出器22の構成は第1の実施の形態におけるものと同じである。一方、第1の実施の形態とは異なり、クロック抽出回路22の出力は、第1の分周回路41を介して位相検出器24の一方の入力端子に接続され、基準タイミング信号生成回路23の出力は第2の分周回路42を介して位相検出器24の他方の入力端子に接続される。この装置においては、信号光が伝達するデータの伝送速度40Gb/s、伝送路として長さ80kmの単一モードファイバにおいて、波長変調量0.1nm、その変調周期10kHz、測定時間1secに設定した。また、第1の分周回路41および第2の分周回路42の分周比率を1/16に設定したところ、測定可能な分散範囲は第1の実施の形態におけるものの16倍に当たる ± 4000 pssec/nmとなった。

【0029】次に、図6を用いて、本発明の第4の実施の形態について説明する。光送信器1-1において、波長変調器12は第1の波長 λ_1 に対して周期 f_1 、波長変調量 $\Delta\lambda$ で波長変調を行い、そこからの出力光は光変調器11において入力信号に応じたデータ変調を印可され、信号光として出力される。また、基準タイミング信号送信回路53においては、入力信号のクロック周波数と等しい周波数を持ち入力信号に対して位相同期された基準タイミング信号を生成し、波長 λ_2 を用いて基準タイミング信号光として出力する。信号光および基準タイミング信号光は多重回路51により波長多重され、伝送路3を伝送する。

【0030】光受信器2-3においては、まず分離回路52により波長分離され、信号光および基準タイミング信号光に分けられる。信号光は光電変換部21において電気信号に変換され、クロック抽出回路22により、クロック信号と再生識別された出力信号に変換される。一

方、基準タイミング信号光は基準タイミング信号受信回路54により光電変換され、基準タイミング信号として再生される。クロック抽出回路22の出力と基準タイミング信号受信回路54の出力は位相検出器24に入力される。この位相検出器24の出力は分散検出器25に入力され、この分散検出器25は既知である波長振幅($\lambda_1 - \lambda_2$)とクロック信号の周波数 f_0 を基に、位相検出器24における位相差の変化量を用いて伝送路における分散値を出力する。

【0031】この装置においては、第1から第3の実施の形態と異なり、分散を測定する時間は有限ではなく常に可能となる。また、光受信器2内に電圧制御発振器34を含む基準タイミング信号生成回路23が不要となるため、安定性がさらに改善された。この時、伝送速度40Gb/s、伝送路として長さ400kmの分散シフトファイバにおいて、波長変調量0.1nm、その変調周期10kHzに設定することにより、伝送路の分散値として0から $\pm 250 \text{ psec/nm}$ を測定することが可能であった。

【0032】次に、図7を用いて、本発明の第5の実施の形態について説明する。この分散測定装置における光送信器1-2は、第1の光変調器61と第1の波長変調器62から成り第1の入力信号から第1の出力光を生成する第1のデータ変調部81と、それと同様の構成をもつ第2から第Nまでのデータ変調部82と、第4の実施の形態におけるのと同じ基準タイミング信号送信回路53を含む。ここで、第1から第Nの入力信号と基準タイミング信号は位相同期されている。第1から第Nまでのデータ変調部および基準タイミング信号送信回路53は、各々異なる波長を出力し、それらは多重回路51により波長多重され送信される。

【0033】光受信器2-4においては、第1の光電変換部71と第1のクロック抽出器72と第1の位相検出回路73と第1の分散検出器74からなり第1の出力信号と第1のクロック信号を出力する第1のデータ復調部85と、それと同様の構成を持つ第2から第Nのデータ復調部86と、第4の実施の形態におけるのと同じ基準タイミング信号受信回路54を含む。基準タイミング信号受信回路54の出力はN分岐され、それぞれ第1から第Nの位相検出回路の一方の端子に入力される。

【0034】この装置においては、第4の実施の形態と異なり、波長多重されたそれぞれの第1から第Nの信号光のそれぞれの波長における分散値を第4の実施の形態におけるのと同様の特性により検出可能であった。

【0035】以上、本発明の分散測定装置および分散測定方法の実施の形態に関して説明したが、本発明はその他の様々な態様により実現可能である。

【0036】まず、本発明の分散測定方法は波長分散を測定するものとして説明したが、これはそれ以外の様々な分散、たとえば偏波分散、モード分散などに対しても

有効な方法である。

【0037】また、本発明の分散測定装置において、クロック信号と基準タイミング信号が同一の周波数の場合について説明したが、これはその関係がその整数倍あるいは整数分の1である場合にも適用可能である。

【0038】また、本発明中の様々な回路、部品に関してはその機能を満たすものであればどのような回路部品を適用しても可能であることは言うまでもない。

【0039】

【発明の効果】本発明の第1の効果は、実際にデータが伝送されている運用システムにおいて、伝送されるデータの品質を落とすことなく、その伝送される波長における分散値を測定することを可能とすることである。

【0040】また、第2の効果は、遠端にあるすなわち光送信器と光受信器の間に長い伝送路がある様な伝送系においても、伝送路の分散値を測定することが可能とすることである。

【0041】また、第3の効果は、分散測定装置が、汎用の部品の組み合わせにより容易に実現可能であることである。

【図面の簡単な説明】

【図1】 本発明の第1の実施の形態を示す図

【図2】 本発明の第1の実施の形態における基準タイミング信号生成回路の構成を示す図

【図3】 本発明における第1の実施の形態の動作を説明する図

【図4】 本発明の第2の実施の形態を示す図

【図5】 本発明の第3の実施の形態を示す図

【図6】 本発明の第4の実施の形態を示す図

【図7】 本発明の第5の実施の形態を示す図

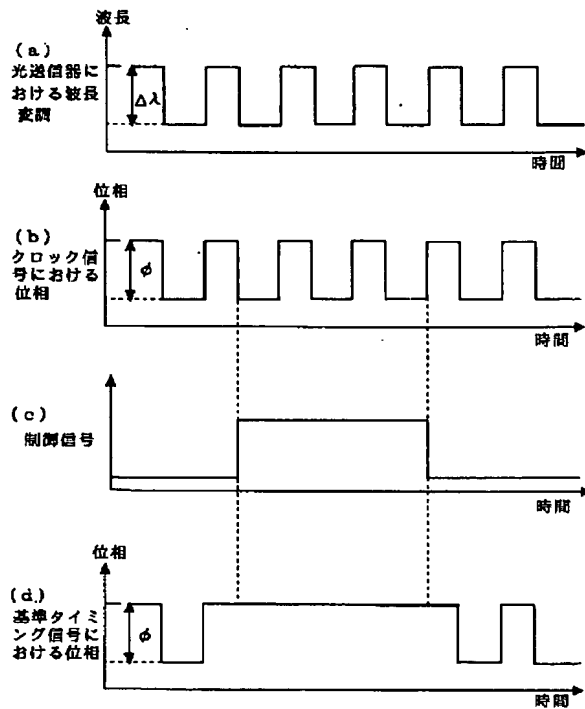
【図8】 本発明の作用を説明するための図

【図9】 従来例を示す図

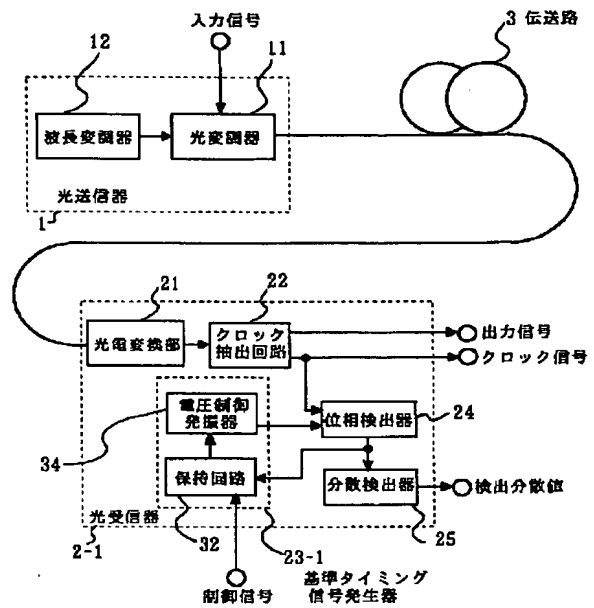
【符号の説明】

1	光送信器
1-1	光送信器
1-2	光送信器
2	光受信器
2-1	光受信器
2-2	光受信器
2-3	光受信器
2-4	光受信器
3	伝送路
11	光変調器
12	波長変調器
21	光電変換部
22	クロック抽出回路
23	基準タイミング信号生成回路
24	位相検出器
25	分散検出器
31	位相比較器

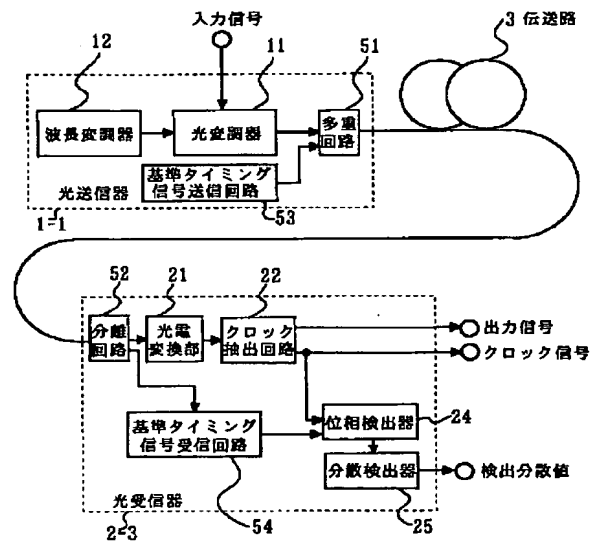
【図3】



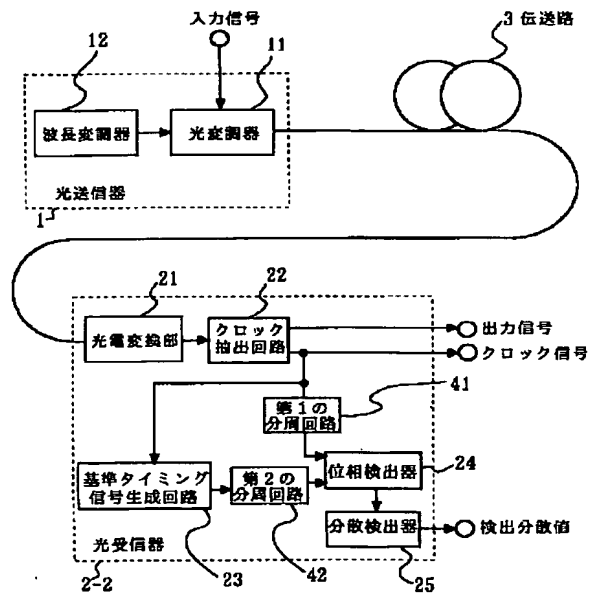
【図4】



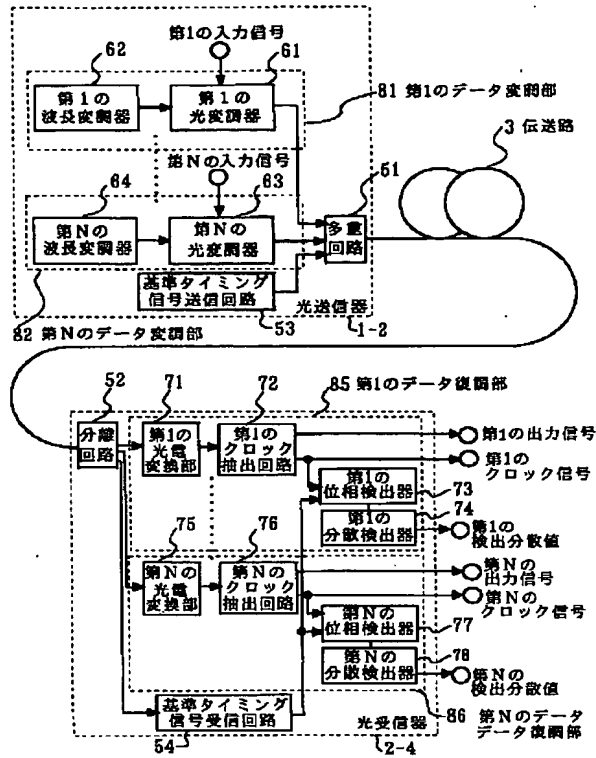
【図6】



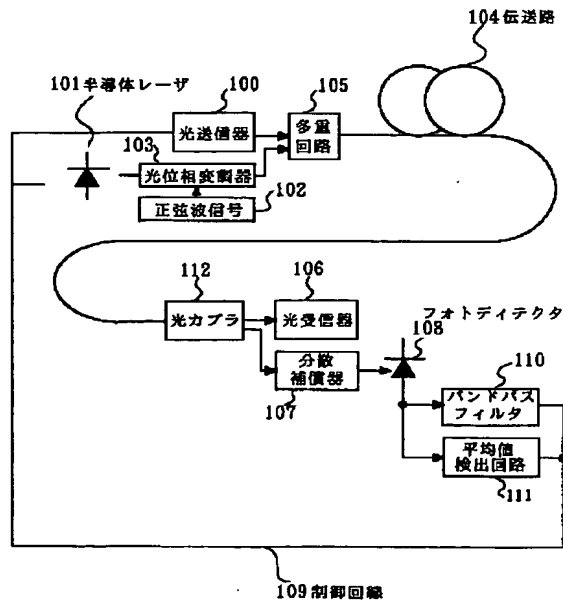
【図5】



【図7】



【図9】



【図8】

